Space Weather Technical Forecast

Issued on Saturday, 15 July 2023 at 13:18 Local

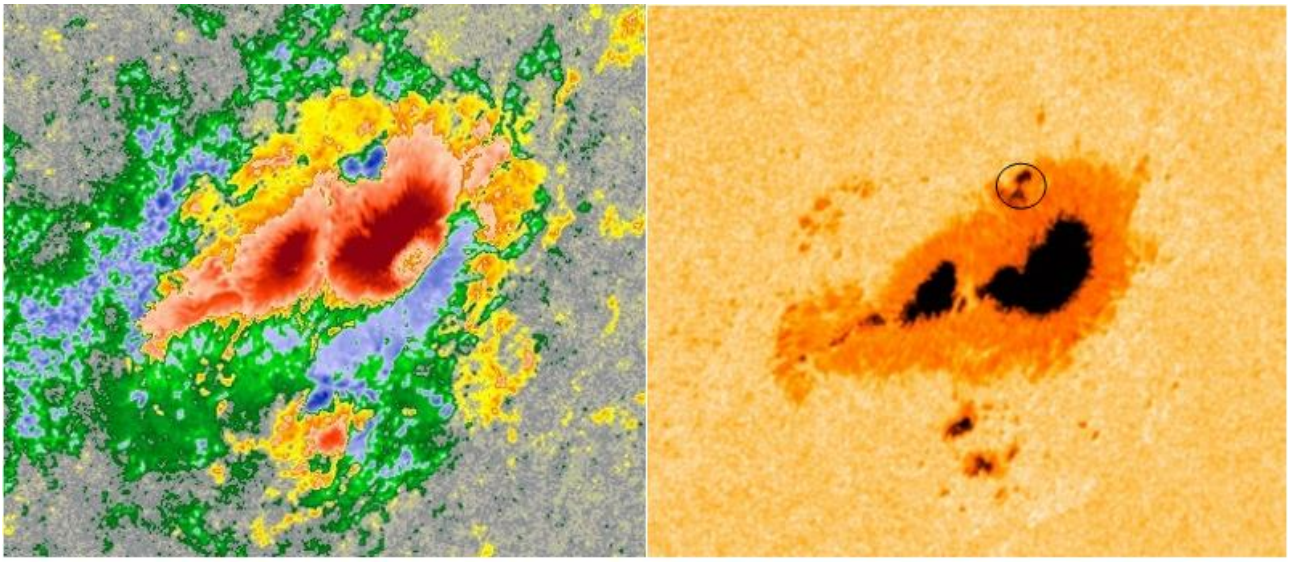
This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Minor/Moderate R1/R2 Blackouts likely throughout. Chance of G2/Moderate Storms Day 1, 3 & 4 (15, 17 & 18 July).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity in the last 24 hours has been Moderate, with several M-class flares originating from AR3363 in the southwest quadrant. The largest was a short-duration M2.9 flare observed at 15/0741 UTC. These produced a couple of CMEs which have been analysed but for which the results are pending.

Figure 0. SDO/HMI Intensitygram (right) and Magnetogram (left) of the most active region – AR3363 – showing a delta magnetic structure (circle)



A filament was also observed lifting off the sun during the evening UTC hours, following a C8.8 flare originating from AR3370. The eruption is visible on SDO AIA-304 imagery, showing an asymmetric halo. The eruption looks faint, however it is likely to be Earth-directed with an arrival at Earth during the early UTC hours of the 17th (Day 3). Confidence is very low though, due to a lack of imagery during that period.

There are currently up the seven sunspot regions on the visible disc. The two most interesting regions on the disc are AR3363 and AR3372. Both are large regions with small delta spots visible, and both have sufficient magnetic flux for an X-flare.

Solar Wind / Geomagnetic Activity: The solar wind, as recorded by DSCOVR at L1, was indicative of two CME arrivals. The wind speed jumped from 380 to 440km/s at 14/1525UTC and

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then from 370 to 500km/s at 15/1030UTC. The density reached 34ppcc after the first CME, followed by a slow decrease to below average levels in the following hours. It then increased to 8ppcc during the 2nd CME. The IMF was initially weak to moderate but became enhanced as the 1st CME arrived, peaking at strong levels around 18 nT. It is now back to moderate levels, around 8nT. The north-south component was largely weak and mostly northward directed, except between 14/1600-1800UTC and 15/0840-1020UTC where it became moderately southward directed. Phi angle was mostly negative (Towards the sun). Geomagnetic activity was mostly Unsettled to Active with a G1/Minor Storm interval 14/1800-2100 UTC during the first half of the period, but largely Quiet during the second.

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV), as observed by GOES16, has been at background levels. High energy electron flux (greater than 2MeV) was at mostly background levels. The 24-hour integrated fluence was below the Active (1e8 integrated pfu) threshold on a decreasing trend. A fluence of 1.76e6 pfu was recorded at 15/0000 UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Activity is expected to be Moderate, with occasional M-class flares and a slight chance of X-class flares. These most likely from AR3372 and AR3363.

Solar Wind / Geomagnetic Activity: Earth is currently experiencing weak CME effects. A couple of Earth CMEs are probable although the result of the analysis are still pending. However if these were to be confirmed, they could give either arrive at Earth or give a glancing blow on the 17th and/or 18th (Day 3 and Day 4). Confidence is low. Little coronal hole influence is expected during this period.

Geomagnetic activity is therefore expected to be predominantly Unsettled to Active through Day 1, Day 3 and Day 4, with an increased chance of G2/Moderate Storm intervals on Day 3 and Day 4 (17th & 18th), due to the CMEs mentioned above. Day 2 is mostly likely to be Quiet.

Energetic Particles / Solar Radiation: The high energy (greater than 10MeV) proton flux has a slight chance of reaching the S1/Minor Storm threshold through the period, should any larger flares occur.

High energy electron flux (greater than 2MeV) may rise briefly over the weekend, but fluence is most likely to remain below the Active (1e8 integrated pfu) threshold throughout.

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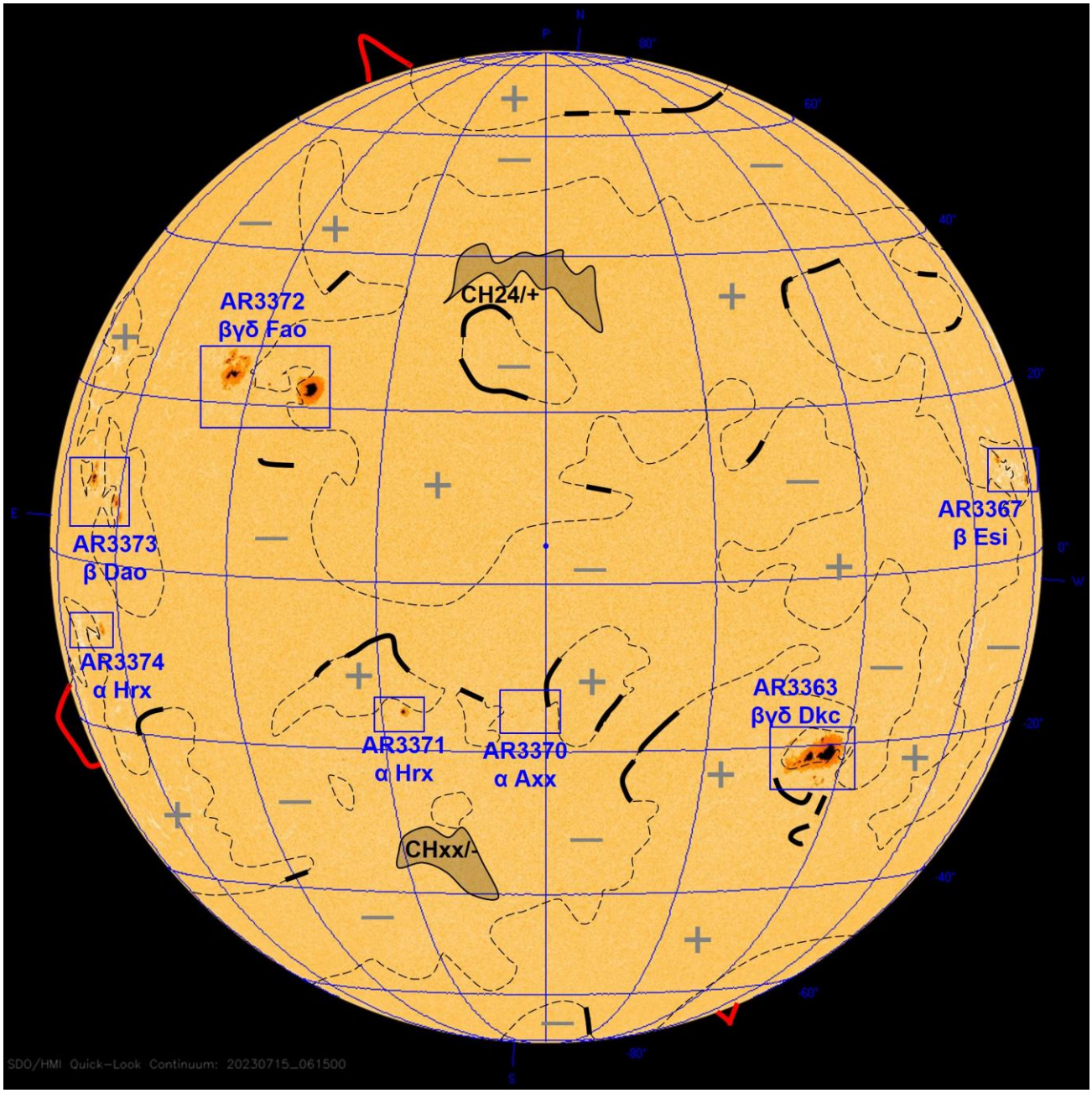
Figure 1. Solar Analysis Valid 15/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

Earth is currently experiencing weak CME effects. A further Earth directed CME is likely from the C8.8 flare that was observed at 14/1844 UTC. The material ejected from this CME looks diffuse and rather disorganised, judging from SDO-AIA 304 images, however it is estimated to be fast with an arrival at Earth in the early hours of the 17th (Day 3). Another CME was observed following the M2.9 flare that occurred at 15/0741 UTC. This has been analysed and while the results are still pending, it is estimated to be fast and may give Earth a glancing blow at the end of the 17th (Day 3) or into the 18th (Day 4).

The coronal hole forecast carries relatively high uncertainty. Regarding CH23, a strong connection occurred on the previous rotation, with solar wind speeds over 600km/s. However this CH appears much-reduced and fragmented this time round, with latest solar wind parameters showing a return to background levels in velocity and density. STEREO-A saw a CIR type signature at the beginning of the period but this may have been masked by CME effects at Earth. The next coronal hole likely to enhance the solar wind is CH24/+ however it is small and a long way north, therefore unlikely to give significant effects at Earth.

Geomagnetic activity is therefore expected to be predominantly Unsettled to Active through Day 1, Day 3 and Day 4, with an increased chance of G2/Moderate Storm intervals on Day 3 and Day 4 (17th & 18th), due to the CMEs mentioned above. Day 2 is mostly likely to be Quiet.

Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	Yes	30	1	40	20
Strong	G3	No	10	1	20	5
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity – Earthbound Coronal Mass Ejections

Awaiting results of the analysis.

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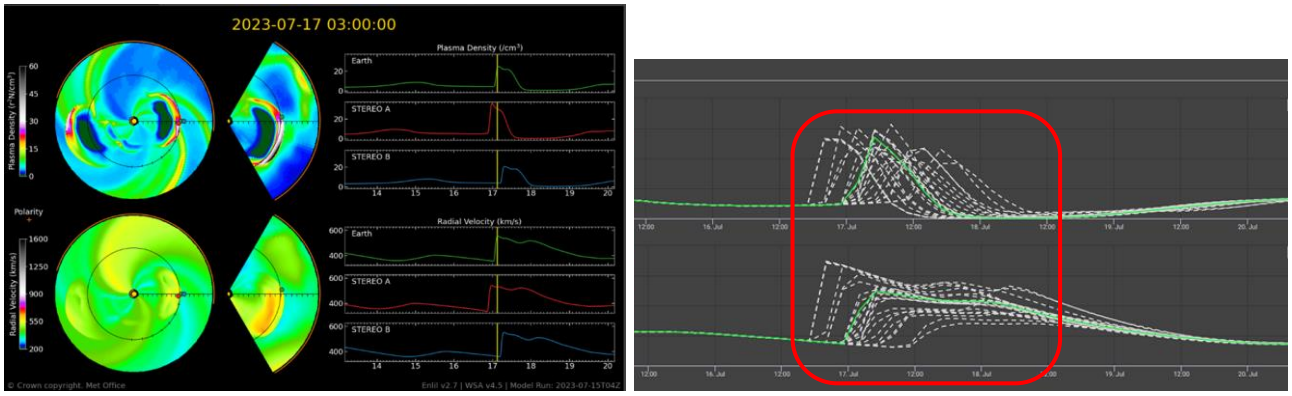
Figure 2: MOSWOC Enlil and ensemble, showing a possible CME arrival on the 17th , with impacts continuing into the 18th



Radio Blackouts - X-Ray Flares:

Solar activity in the last 24 hours has been Moderate, with several M-class flares originating from AR3363 in the southwest quadrant. The largest was a short-duration M2.9 flare observed at 15/0741 UTC.

There are currently up the seven sunspot regions on the visible disc, AR3370 having re-emerged as a simple Axx/Alpha region. AR3362 has faded and has therefore been removed from the tables. The two most interesting regions on the disc are AR3363 and AR3372. Both are large regions with small delta spots visible, and both have sufficient magnetic flux for an X-flare. AR3373 is slowly developing, with proliferation of spots whereas AR3374 has seen its umbra shrinking, leading to a class simplification (from Hsx to Hrx). AR3367 is becoming more difficult to analyse as it's approaching the west limb, so its classification will be maintained as it rotates off. AR3371 remains a small and simple unipolar region.

Activity is expected to be Moderate, with occasional M-class flares and a slight chance of X-class flares. These most likely from AR3372 and AR3363. Although some regions will leave the disc during the period, far side soundings and far side CME activity suggest the presence of several fairly active regions to rotate onto the disc in the coming days. As such, the flare risks are held constant for now, although the oncoming regions cannot be assessed until they become visible on the east limb.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	60	60	60	60
Very Active	R3 to R5 X Class	No	10	10	10	10

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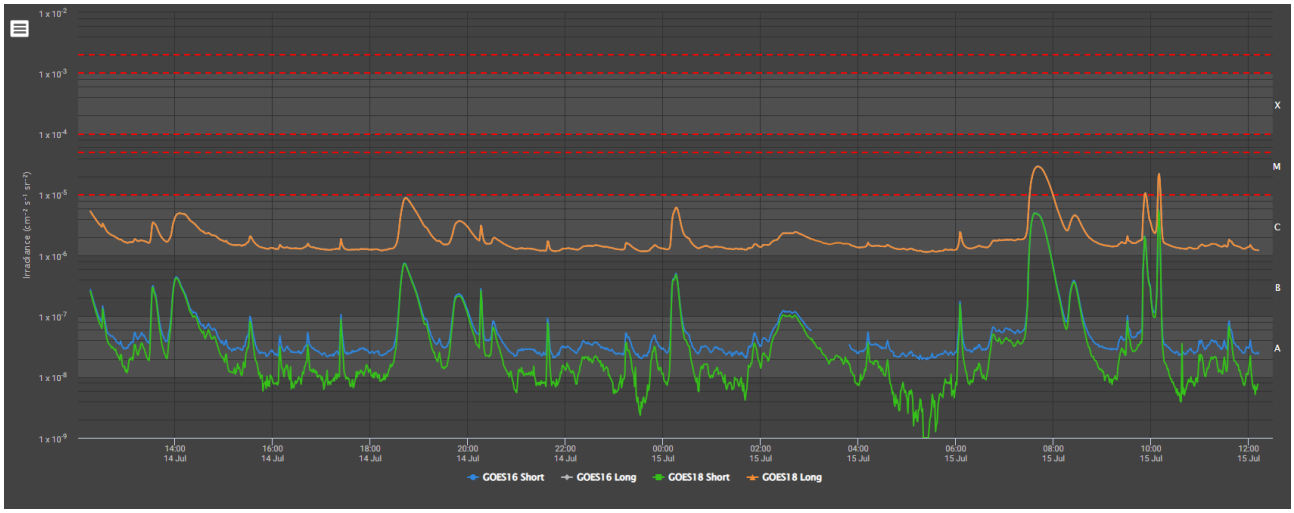
Figure 3: Latest X-ray flare activity, as observed by GOES-16.



Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux, as observed by GOES16, is currently at background levels. There has been some minor enhancement in response to some of the past week's M-class flares, but these have now eased.

The probability of S1/Minor Radiation storm level has been slightly raised in response to the recent increase of activity from AR3363, being in a geo-effective location. The daily risk stays roughly constant though - while some western regions are about to cross the horizon onto the far side and rotate away, further groups are expected to emerge from the far side and take over.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	15	15	15	15
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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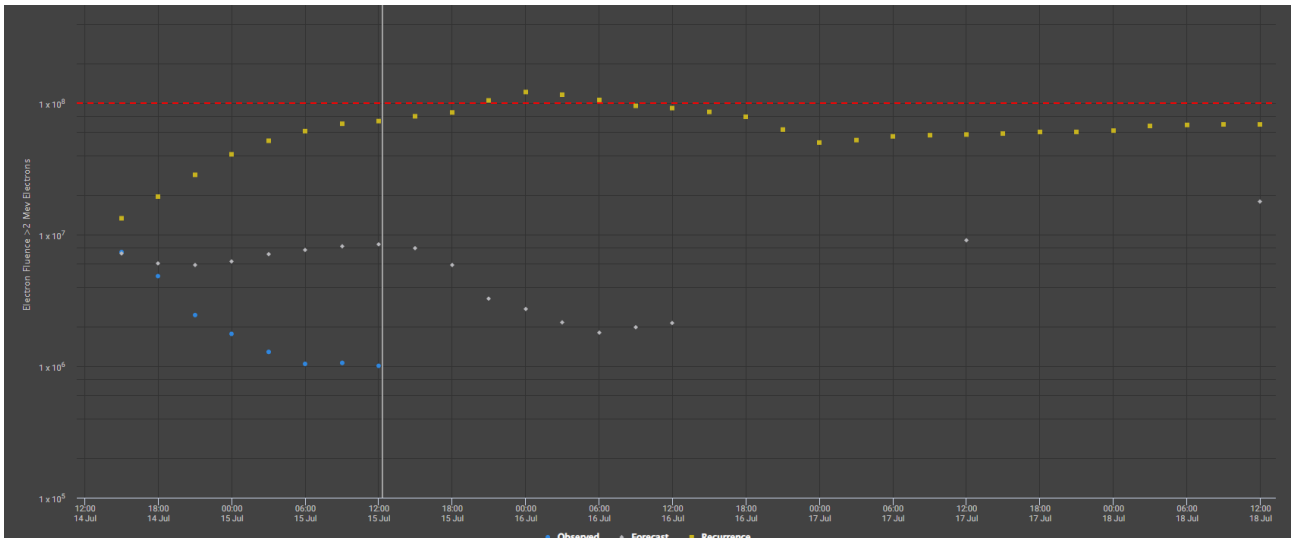
High Energy Electrons Event (≥ 2MeV):
High energy electron flux (greater than 2MeV) at GEO has been at mostly background levels, with a declining trend, likely due to recent CME arrivals. An increase of electron flux in the Van Allen belt is possible due to the combined effect of the CME and potential fast wind enhancement. However, a possible further CME later in the period may cause another suppression, although this CME has yet to be fully assessed. Any flux rise through the weekend has low confidence in magnitude.

The associated 24-hour fluence is expected to remain below the Active (1e8 integrated pfu) threshold, with REFM giving a reasonable guide, although it won't be taking account of any further CME arrivals. There may be a brief rising trend over the weekend, but the potential further CME arrival is likely to suppress this once again. It is considered most likely that fluence will remain below Active levels throughout.

GEO Electron Environment Probability (Exceedance)	Level ($cm^{-2}\,sr^{-1}\,day^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	5	10	10
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 4: Latest Met Office REFM output, considered to provide good guidance.



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